Enabling Fuel Cell Bus Deployment

Technology from Linde

LeadIng.

THE LINDE GROUP

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About Linde

THE LINDE GROUP

65,500 Employees in more than 100 Countries

In 2014, $17.9 Billion Revenue

Headquartered in Munich, Germany

5,000+ Employees in the USA

Annually, Over $2.0 Billion Sales

Headquartered in Murray Hill, NJ

As a result, we see many combined bus and passenger car stations

Linde reference projects

Hafencity, Hamburg

Shell Sachsendamm, Berlin

OMV, Stuttgart

TOTAL/CEP, Berlin

AC Transit, SFO Bay

Bolzano, Italy

Key facts (cars, buses, FLTs)

—More than 100 hydrogen stations equipped in 15 countries

—Approaching 2.000.000 successful fuellings

—Leading supplier of hydrogen fuelling technologies

Key Learnings

— Technological maturity reached

— High level of standardisation reached

— High performance fuelling already installed

— Standardised, high-performance stations for buses necessary to achieve best economics

Largest H_2 Station in the World

1000 kg/day is happening today

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BMW, Spartanburg, SC

350+ Material Handling Vehicles

Approaching 1000 kg/day

100% Uptime Since Installed 2010

Linde H_2 Bus Stations

Aberdeen Scotland
- 15 Buses

Shell Sachsendamme
Berlin

AC Transit (2 Stations)
Oakland, CA - 12 Buses

IT Bolzano Italy-
15 Buses

HafenCity
Hamburg - 20 Buses

Linde plays a major role in all the major target markets for Fuel Cell Buses.

Linde supplies high-purity Liquid Hydrogen, Compressed Hydrogen, and Station Equipment in all these target areas.

Linde's partner cities within the NewBusFuel project.

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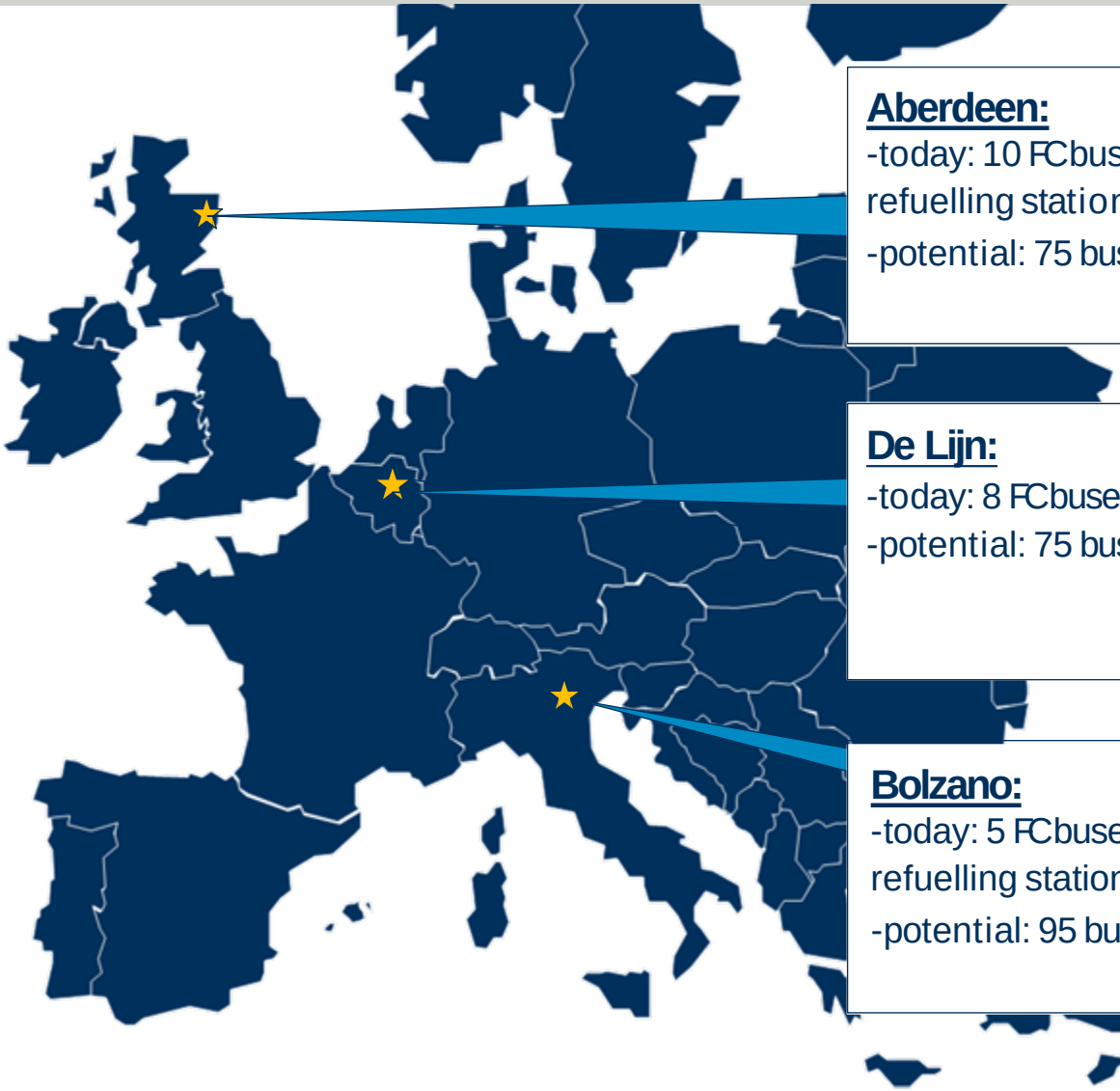


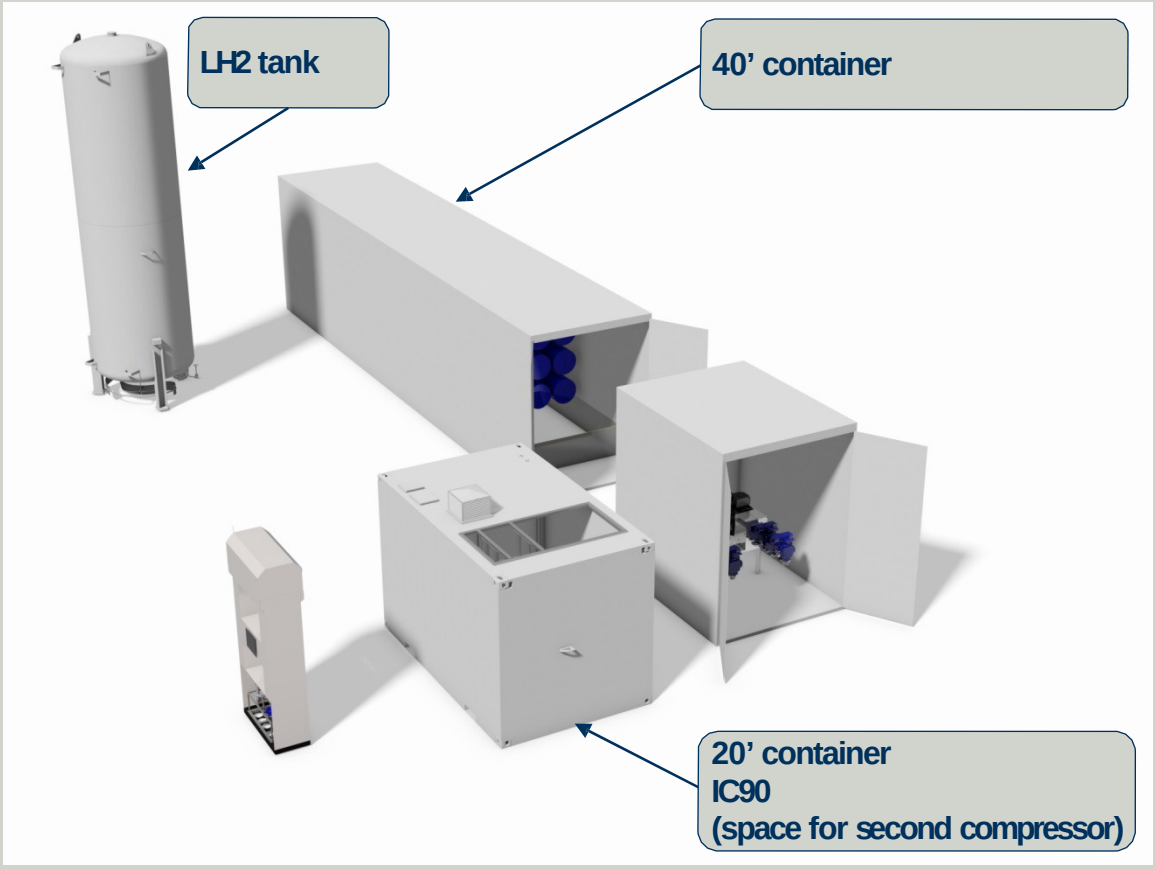
Aberdeen:
-today: 10 FCbuses, existing refuelling station from Linde/BOC
-potential: 75 buses in operation

De Lijn:
-today: 8 FCbuses
-potential: 75 buses in operation

Bolzano:
-today: 5 FCbuses, existing refuelling station from Linde
-potential: 95 buses in operation

Layout I (10 buses)

250kg H_2



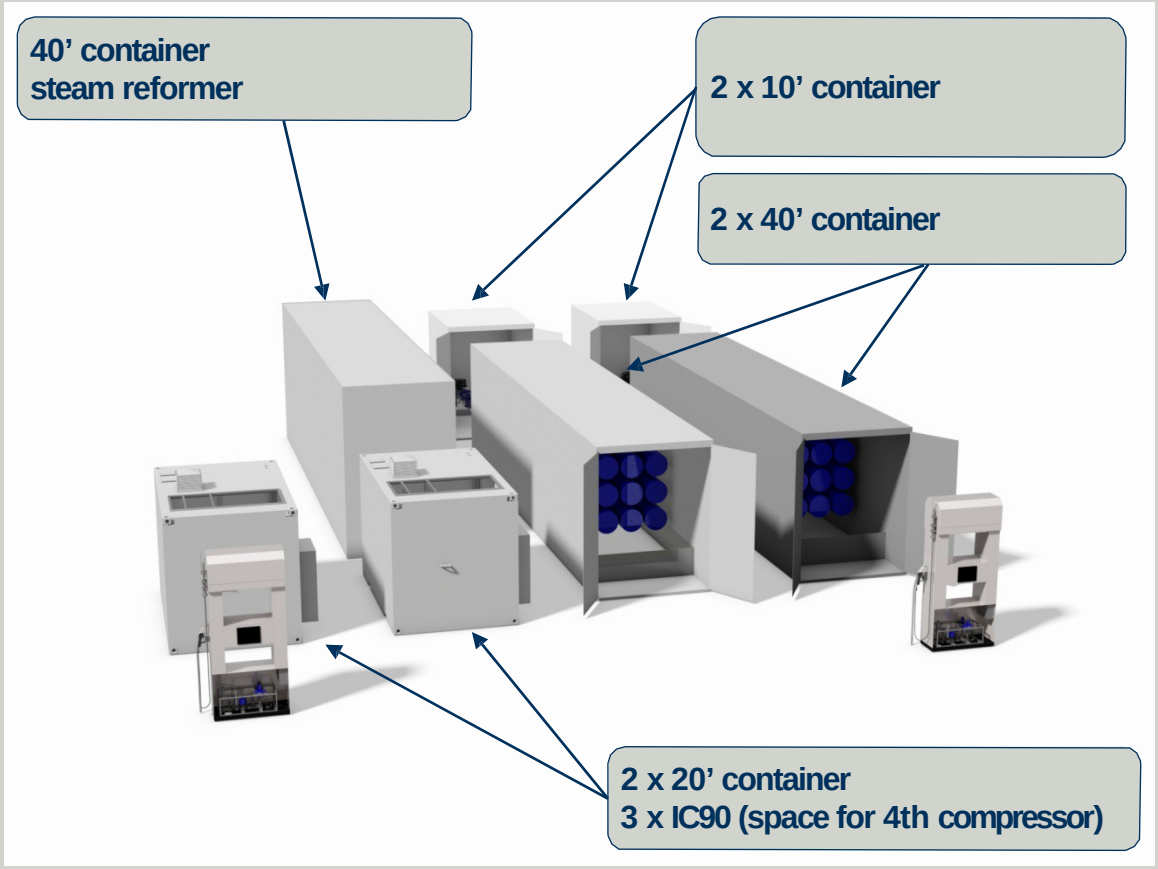
Layout I

Layout & performance

- Footprint: **30ft x 60ft**
- Power requirement : **110kW** for IC 90
- Compressor type: **Ionic compressor for H2 – IC90**
- Supply: **liquid**
- Compressor capacity : **30 kg/h**
- Fueling protocol: **SAE J2601-2 heavy duty vehicle**

Layout II (30+ buses)

750kg H_2



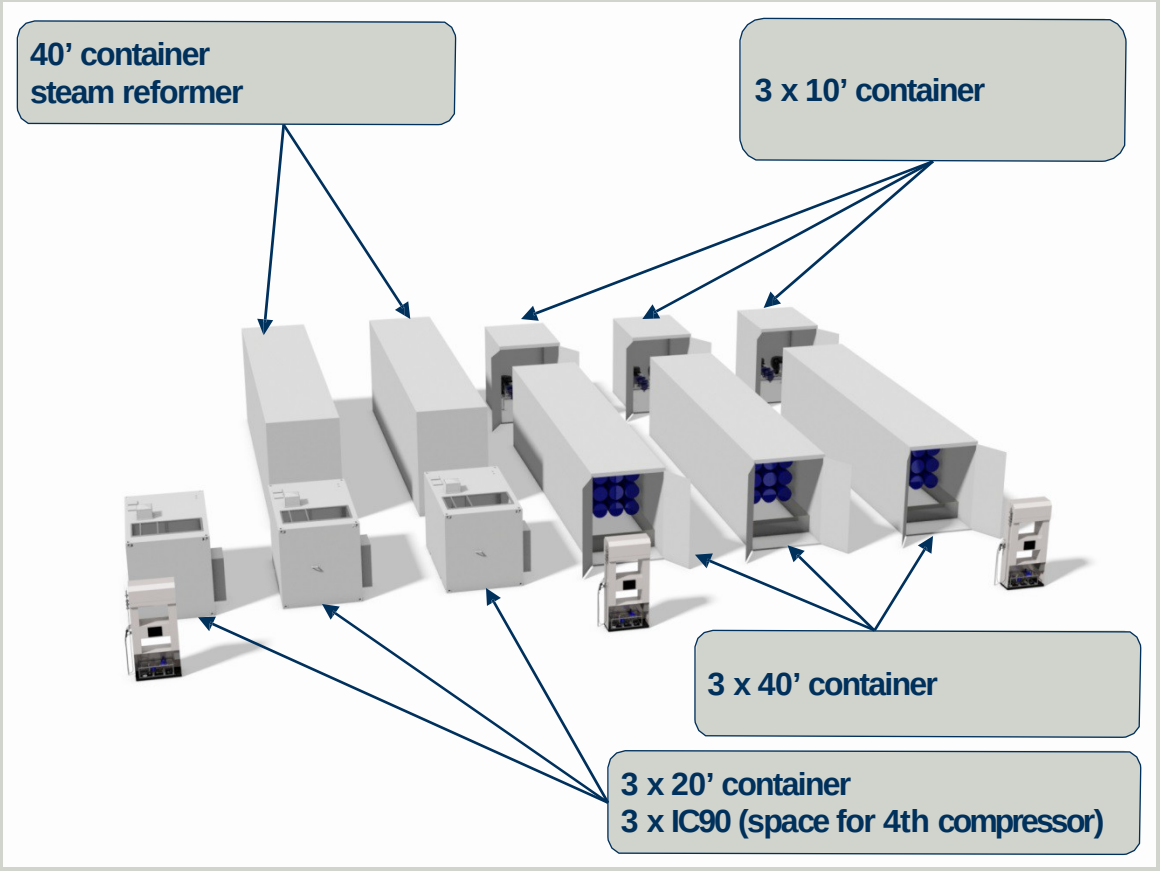
Layout II

Layout & performance

- Footprint: **60ft x 60ft**
- Power requirement: **220kW** (110kW per IC90)
- Compressor type: **Ionic compressor for H2 – IC90**
- Supply: **gaseous**
- Compressor capacity : **60 kg/h**
- Fueling protocol: **SAE J2601-2 heavy duty vehicle**

Layout III (40+ buses)

1000kg H_2



Layout III

Layout & performance

- Footprint: **77ft x 60 ft**
- Connected load: **330kW** (110kW per IC90)
- Compressor type: **Ionic compressor for H2 – IC90**
- Supply: **gaseous**
- Capacity: **90 kg/h**
- Fueling protocol: **SAE J2601-2 heavy duty vehicle**

A bus station for 30 buses will be really small

Future Plot Optimizations Expected

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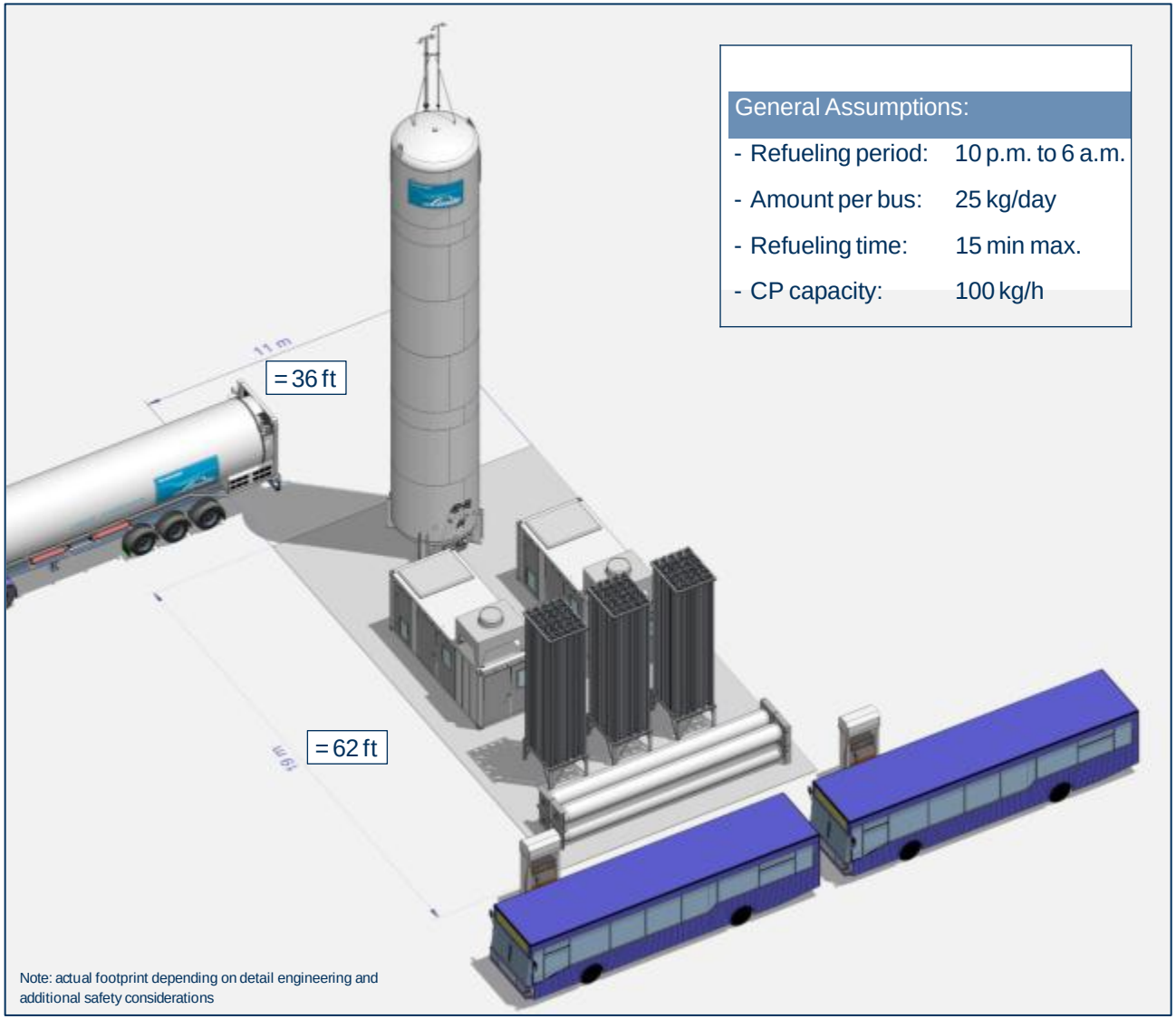

General Assumptions:	
- Refueling period:	10 p.m. to 6 a.m.
- Amount per bus:	25 kg/day
- Refueling time:	15 min max.
- CP capacity:	100 kg/h

Note: actual footprint depending on detail engineering and additional safety considerations

HRS for 30 buses

Capacity	750 kg/d
Footprint	~ 200 m²
	~ 2.200 ft²
Length	19 m / 62 ft
Width	11 m / 36 ft
Cryopumps	4
Dispensers	2
Supply	LH2
Storage	~ 2.500 kg 3 days

60 buses: Only 60% more space required

Future Plot Optimizations Expected

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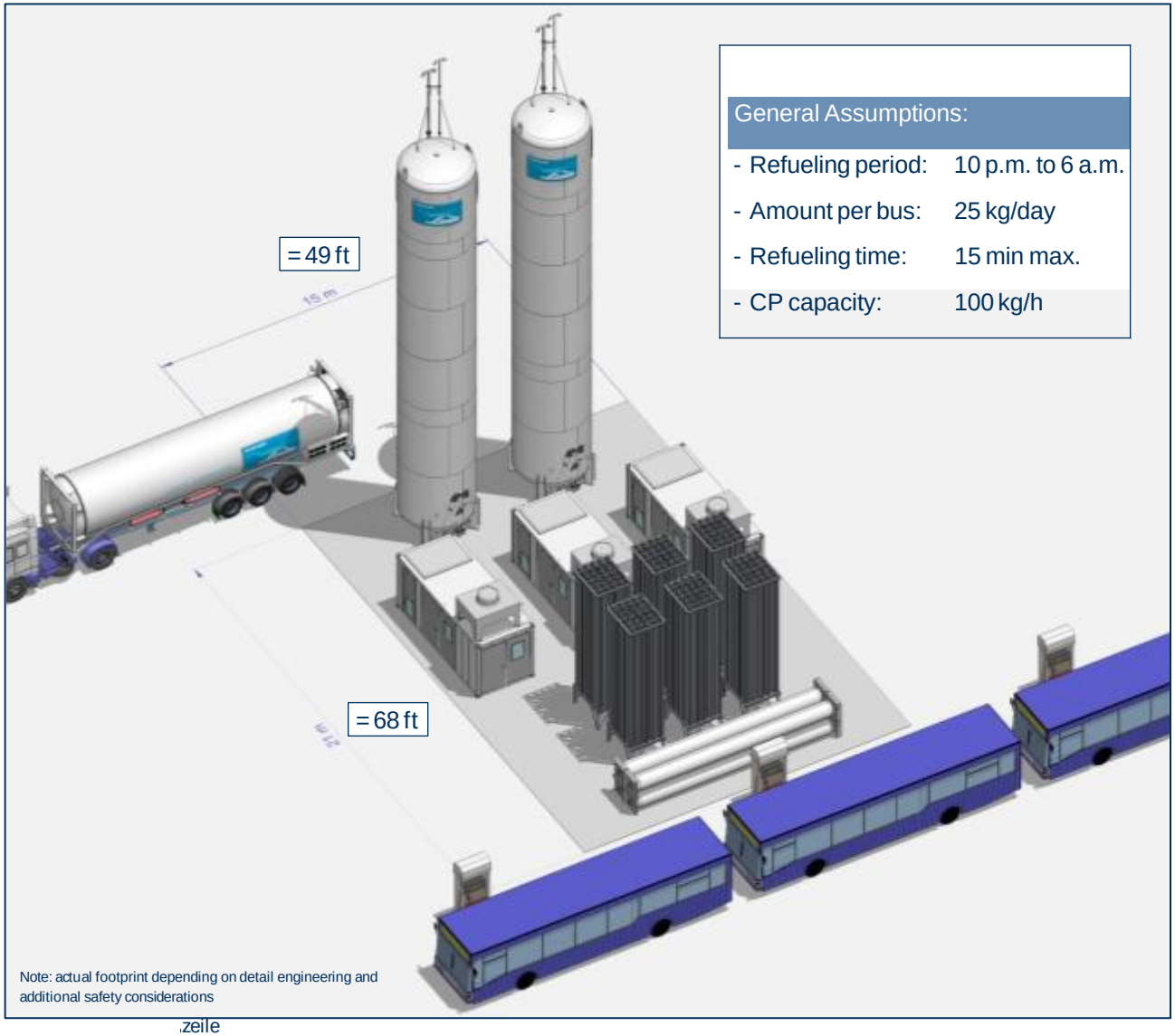

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Note: actual footprint depending on detail engineering and additional safety considerations

HRS for 60 buses

Capacity	1.500 kg/d
Footprint	~ 320 m²
	~ 3.400 ft²
Length	21 m / 69 ft
Width	15 m / 49 ft
Cryopumps	6
Dispensers	3
Supply	LH2
Storage	~ 5.000 kg 3 days

120 buses are served on 530 m² / 5.660 ft² of space

Future Plot Optimizations Expected

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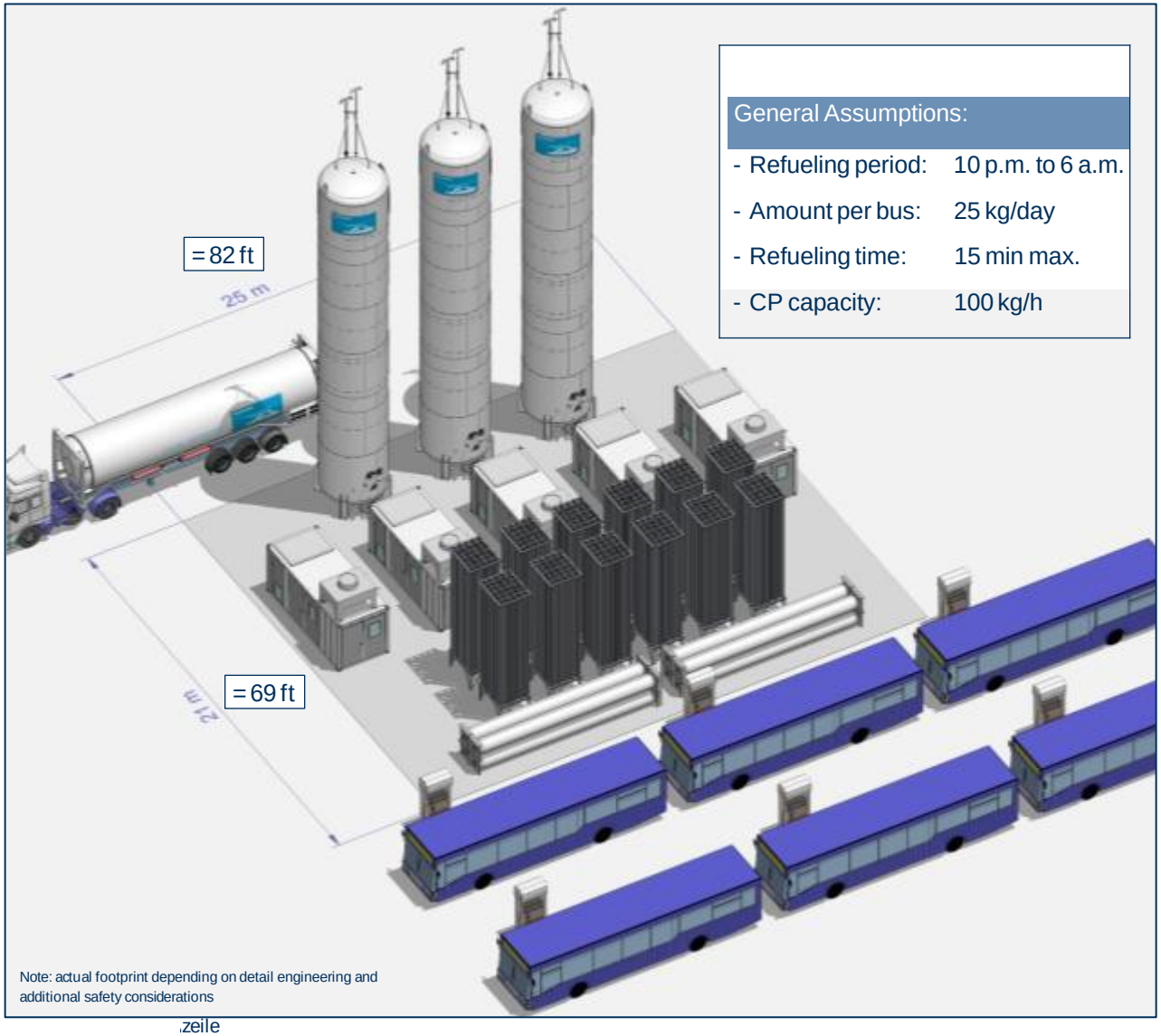

General Assumptions:	
- Refueling period:	10 p.m. to 6 a.m.
- Amount per bus:	25 kg/day
- Refueling time:	15 min max.
- CP capacity:	100 kg/h

Note: actual footprint depending on detail engineering and additional safety considerations

HRS for 120 buses

Capacity	3.000 kg/d
Footprint	~ 530 m²
	~ 5.700 ft²
Length	21 m / 69 ft
Width	25 m / 82 ft
Cryopumps	10
Dispensers	6
Supply	LH2
Storage	~ 7.500 kg
	2.5 days

Onsite electrolysis, storage and compression
Future Plot Optimizations Expected

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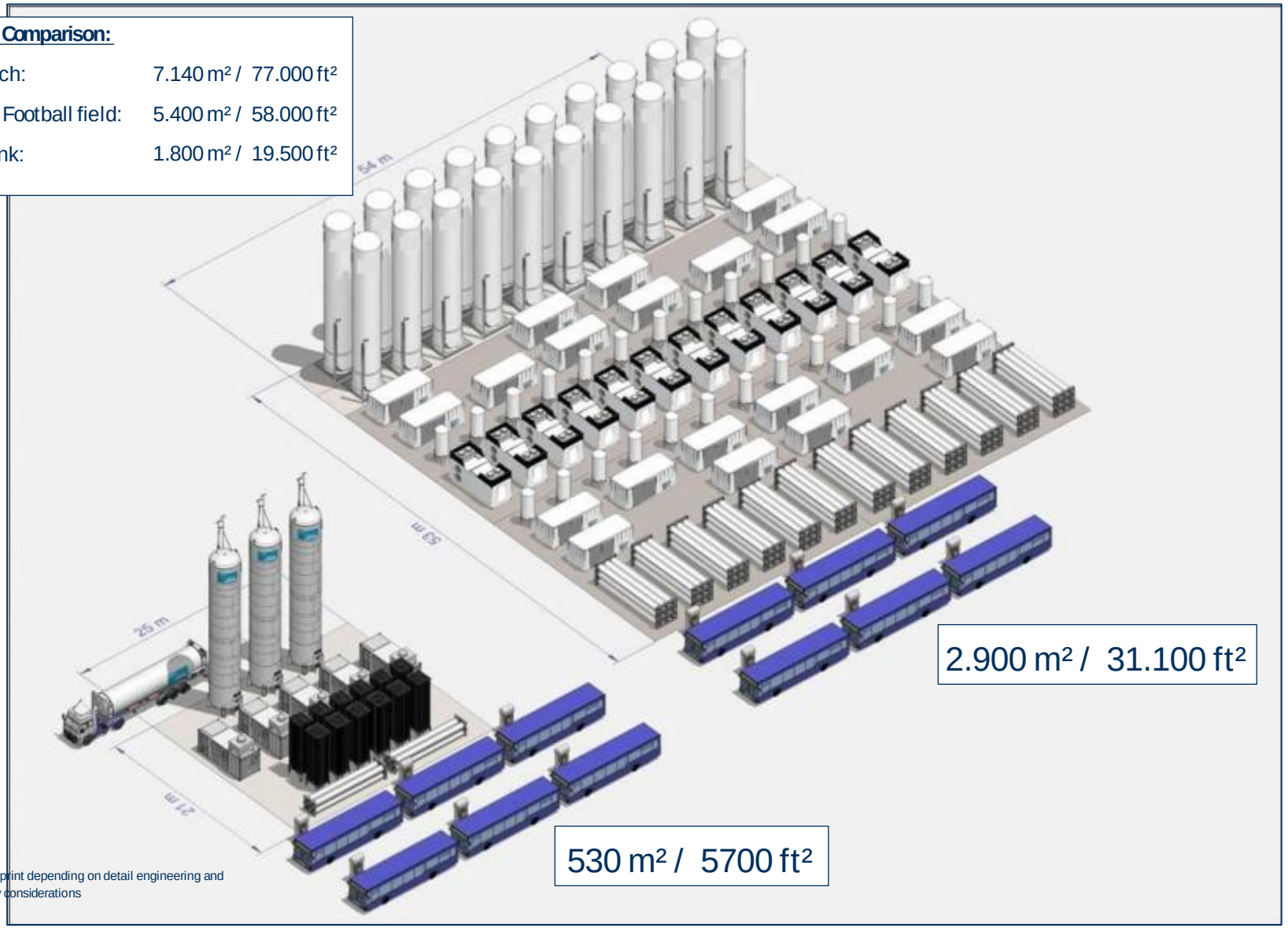
Everyday Comparison:

Soccer pitch:	7.140 m² / 77.000 ft²
American Football field:	5.400 m² / 58.000 ft²
Hockey rink:	1.800 m² / 19.500 ft²



Note: actual footprint depending on detail engineering and additional safety considerations

Thank You

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